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ABSTRACT

Computer-assisted instruction (CAI) has not been cost-effective, despite its instructional effectiveness. This financial failure can be attributed to many factors, including: oversell of CAI capabilities, poorly authored content, expensive and unreliable hardware, an educational bureaucracy resistant to innovation, and the decentralized nature of American education which works against the widespread implementation of CAI systems. Educators can achieve a high level of awareness of CAI's complexity, and thereby promote its success if they take the following steps: 1) carefully assess needs and document objectives; 2) establish priorities for CAI use; 3) commit resources to CAI on a long-term basis; 4) study the appropriateness of any existing system before adopting it; 5) release faculty for program planning and development; 6) train cores of CAI specialists; 7) adjust faculty load formulas according to new needs; 8) review the impact of CAI on other aspects of the school system; 9) integrate all CAI into the total school program; 10) provide the necessary facilities to house the system; 11) offer school-wide orientation programs; 12) plan so as to avoid wasting students' time; and 13) use a team approach in implementing CAI. (PB)

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THE ECONOMICS OF COMPUTER AIDED INSTRUCTION

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INTRODUCTION

Computer Aided Instruction (CAI) has been around long enough to say that "traditionally" something is true about CAI. Traditionally, CAI has been an economic failure. The reasons for this are that, for one reason or another, the people who have attempted to manage CAI projects have not properly managed the financial aspects of the undertakings. And also, the projects were not well-managed due to some misunderstandings of what computers are and what they can do.

To address the latter problems, computers were not designed for instruction. Computers are basically designed and constructed for numerical analysis, and numerical analysis has certain properties that allow computers to process alphabetic information in addition to numbers. Computers need much faster means to transfer data from their mass storage facilities to their processing facilities.

Another problem is the belief that there is one best language for a certain kind of computer application. The best language for an application is the one the programmer knows best. An auxillary to the best language problem is the idea that you can teach classroom teachers to program and have them sit down and develop CAI materials. You cannot. Only in certain, rare individuals is this possible.

As a starting point for our consideration of the financial aspects of CAI, let us consider the various kinds of CAI.

COMPUTER SUPPORT OF INSTRUCTION

We can define three subtopics in computer support of instruction:

Computer-assisted instruction,
Computer-managed instruction (CMI),
Learning simulation (actually a subtopic of CAI).

COMPUTER-ASSISTED INSTRUCTION

Typically, four instructional strategies have been employed in implementations of CAI:

Drill-and-practice,
Tutorial,
Dialog,
Simulation and gaming.

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In the drill-and-practice strategy, the student is presented with practice questions and problems through the CAI system. The student is typically given immediate information as to the correctness of his answer. Depending on his success on a series of problems or questions, the student may be branched to a more or less difficult problem set. The instructional material preceding the drill-and-practice can be presented via a "tutorial" CAI system or by other media.

A tutorial CAI system is designed to present the initial material to be learned. For example, in "conventional" instructional systems the material is initially presented via lecture and/or printed text. The lecture may be "enriched" through question and answer exchanges and discussion among the teacher and students. The CAI system can present the textual material by print or some type of display and ask pertinent questions concerning the material immediately presented. Some drill-and-practice can be combined in the tutorial strategy.

A strategy developed around a dialog can be very instructive to the student, but it generally consumes many man-months in development and a large amount of hardware resources while running. The dialogue strategy is the "Socratic" method in which the student is taught (learns) through a series of questions and answers, succeeding questions based on preceding answers. This strategy requires complex branching procedures and the storage of vast amounts of text.

The simulation and gaming strategies are developed around artificial situations paralleling the kinds of real problems the student is expected to be able to solve as a result of having completed the course. The CAI system provides the vehicle for interaction between the simulation model or game and the student.

Simulation is a new topic in many ways. As educational institutions benefit from the more cost effective approaches of CAI and CMI, it seems reasonable that additional instructional enrichment should be offered through the technique of learning simulation. This involves the use of time compression techniques and decision role techniques to provide the student with the opportunity to learn and play the role of significant participant. For example, it is quite possible to provide the role and decision-making aspects of an executive of a business firm that proceeds through a 20-year time cycle within an instructional period of four hours or less. One simulation of this type has been developed at Florida State University (11), providing three parameters in the operation of a beer corporation. One parameter is for an inflation cycle, one is for a normal business cycle. All of these are in terms of making business judgments, such as how much beer to produce, how much to spend on advertising, how much to enhance the distribution system, and what will be the outcome, for this particular three month cycle? Students who take part in the simulation appear to be remarkably intuitive, and show great conceptual development in perceiving what happens after they operate through a two to four year depression, and then go into a very affluent time. They seem to experience a "Vio'a!" effect, and a tremendous fascination.

Learning simulations are an extremely promising area for this coming decade. Educators who come to grips with using this technology in this way can turn on students to a new way of learning, (See: 18; 14).

Course Development in CAI: In a very general way we can divide the process of producing a CAI course into the following steps:

1) Definition of the course content. (Specifications of what is to be taught.)

2) Division of the course content into internally consistent, logically related "modules" (lessons).

3) Separation of the modules into items (steps, "atomic" units of content, basic elements for which further breakdown would cause the items to become meaningless).

4) Organization of items and modules.

5) Coding of the course into a computer readable format.

6) Evaluation of the course.

7) Revision of the course.

8) Evaluation of revision.

9) Use of the course.

10) Continual evaluation and revision.

A significant benefit derived from CAI has been the requirement for analysis of instructional systems, and the development of testable procedures for instruction. Analysis of the techniques and strategies employed has yielded some interesting information which can, in some cases, be applied to conventional instruction.

1) Summary notes at the end of a lecture or other learning session appear to be more complete and useful than real-time note-taking during the session.

2) Lesson-Organization Strategies: The Carrot-on-a-Stick Strategy employs constant monitoring of the performance of the student, and the lesson is designed to alter the level of the material to constantly slightly surpass the level of ability of the student. This causes the student to engage in intellectual activity more frequently than when he is merely regurgitating by rote or following known procedures. The Compensatory Strategy attempts to identify what aptitudes the student does or does not possess which correlate highly with success in the completion of the course of instruction. The lessons are presented based on the student's aptitude rather than his knowledge of content. The Capitalization Strategy bases the instruction on the well-developed capabilities and aptitudes of the student.

The lessons develop from the student's strong areas to his weak by incremental examples and analogies. The compensatory strategy appears to work well with younger children, and the capitalization strategy with older children. The carrot-on-a-stick strategy works well across age-levels and aptitudes, but its effectiveness seems to be related to personality characteristics. Certain students with low confidence and traits of insecurity seem to learn best by employment of the capitalization strategy with small increments in difficulty between steps, with a gradual increase in difficulty until the carrot-on-a-stick strategy can be employed. This later strategy appears to be very useful in developing the capability to successfully cope with new problems and situations.

3) Error interpretation is critical in all instructional environments. Analyses should be made of why each kind of error occurs, what classes of error do occur, and whether the errors are due to lack of skill or knowledge on the part of the student (failure of the teaching process due to a poorly designed course), or faulty test and evaluation procedures and items.

4) Deferred repetition produces better retention than does immediate repetition of material.

5) Subject-matter expertise is not a sufficient criterion for developing CAI or conventional instructional programs. Subject-matter expertise must be combined with knowledge of the instructional process to develop adequate courses. Considerable training is required to develop teaching capabilities, especially in the area of utilization of multi-media systems.

6) Individualized instruction should take the student's "preferred type of reinforcement" into account. Everyone is not turned on by the same things.

7) Different kinds of lesson materials should be developed for reading materials for knowledge of content and for reading materials to learn to read. If the student has difficulty with the language level of the material to be read for content, then he will retain little of the content. Also, reading materials to demonstrate correct usage of the language and to develop vocabulary require different structures and techniques than content-oriented materials.

COMPUTER MANAGED INSTRUCTION

Employing computer managed instruction (CMI), the teacher interacts with the computer to provide instruction to a relatively large number of students. CMI can be defined as an automated approach to individualized instruction that implements the functions of:

Diagnostic evaluation with learning prescriptions.

The limited use of CAI for drill and practice or conceptual enrichment.

Counseling of the students as to adaptive learning strategies and appropriate career development,

The development of a scheduling system for optimal match of students with learning resources, which include not only the computer but also other types of media devices including teachers,

The development of an appropriate student instructional record scheme which shows the educational process working on a day to day basis,

Learning simulations.

Rather than encoding the learning materials within the computer system, as does CAI, CMI depends upon the availability of conventional printed and multi-media materials. CMI uses the capability of the computer to manage the progress of the student through a particular course of instruction, testing at many points using CAI techniques for remedial or enrichment purposes. The resulting performance data base provides for the constant development of more appropriate versions of the instructional process. A number of projects have used CMI in their operation: Flanagan's Project Plan (17), Coulson's work at Systems Development Corporation (16), and O'Dierno's work at New York Institute of Technology (19). In these projects students are guided to their learning materials based on progress information supplied by the computers to their teachers. Student instruction and testing are all performed with conventional paper and pencil procedures and the data are fed through the computer via optical scanner. In turn, reports are supplied to the teachers of the students in terms of some kind of hand carrying or mailing scheme.

Diagnostic evaluations and the learning prescriptions that occur within a computer-terminal-mediated interaction between the student and the CMI system can provide three significant features:

1) They allow for the inclusion of CAI techniques and learning simulations when desirable.

2) They have the virtue of insuring that students are responsible for correctness of information both going in and coming out of the system.

3) They allow more facilitated feedback so that the student receives his next learning assignment immediately, as opposed to waiting 24 hours or more.

Diagnosis and prescription: The individualization process under CMI is primarily based on an operational understanding of diagnostic evaluation and learning material prescription techniques offered via an interactive terminal. With the terminal interaction, such multiple dependent measures as error rates, error patterns, latencies, and the methodological techniques of sequential testing and learning optimization models can be just as readily applied here as they are in CAI. (10) Hopefully, these will lead to a better representation of the diagnostic evaluation and learning prescription process for each child. In turn, CAI techniques, the encoding of actual learning materials when deemed appropriate, can be utilized within this approach. CAI can provide improved dialogue in regard to learning relationships, especially concerning those among behavioral objectives utilized within a course. Experience is demonstrating that most students cannot grasp behavioral objectives, that they need some dialogue, and some examples, to clarify the objectives. CAI can also provide a dialogue in regard to adaptive strategies to be employed by the student, some of the good, rough-and-ready kinds of ways of getting through the course that other students have suggested and CAI can offer for consideration. And CAI provides for conceptual remediation and drill and practice on algorithmic learning processes.

The particular advantages found in CAI have primarily dealt with the fact that for those students who are not coming up to normative standards, the CAI seems to have its greatest payoff. This, in the elementary school, is in terms of providing simple things like arithmetic drill-and-practice. In high school and college, for students having difficulty in physics, or chemistry, or psychology, it is giving them an opportunity to get significant practice with feedback on homework problems. Evidence indicates that homework is highly beneficial, yet the entire educational spectrum appears woefully deficient in offering students sufficient practice opportunities. CAI can offer students, even on a voluntary basis, opportunities to practice required behaviors and to get feedback.

A study recently completed at Florida State University looked at the particular kinds of operations in a fairly complex and difficult set of mathematics material dealing with Boolean algebra. The materials indicated that the student has to learn a definition, and learn an algorithm, and then put those together to do something called a proof. Mathematicians consider all three of these important. In terms of giving feedback on these fairly difficult materials, four different types of time delays were selected. One was immediate feedback, which means approximately half a second to a second. One was systematically delayed 10 seconds, one was given at the end of the session (typically 50 minutes), and the fourth group was given feedback after 24 hours. Surprisingly, preliminary analysis shows that the end-of-session group ran about 15% better, demonstrating that, with the many kinds of educational content, different requirements, differential student adaptation and entry behaviors, immediate feedback might, in fact, be very detrimental in comparison to giving the student an appropriate amount of reflection time. If this study holds up under repetition, its implications for the educational world can influence methods of instruction, and its implications for design of computer systems is even more dramatic. Designing computer hardware that can wait for response, or accumulate responses, can conceivably save money.

Counseling. In CMI, students can continuously be given opportunities to review CMI courses and to gain information regarding their progress. They can ask questions about learning problems, adjustment processes, and their concerns about their future careers. This last is a kind of question that students appear very concerned about. Since all of these questions are important from the student point of view, CMI counseling activity relieves many of the demands on the human counselor or instructor within the system (5).

Scheduling Systems. The CMI system can be provided with a scheduler much like that of an airline, that matches human resources with learning materials in an appropriate and, hopefully, optimal manner. Through the development of an overall student records scheme, monitoring can provide a good empirical basis for rational judgments about how to improve the coordination of the human element with particular books, film or other resources.

COMPUTER-ASSISTED TESTING

A very promising application of the computer to education is in the area of computer-assisted testing. By use of a terminal, conventional tests may be administered and the data stored for item analyses and development of norms.

The development of computer-oriented testing procedures, while now in its infancy, shows promise. For example, computer-assisted "branched" testing is based on the development of "multilevel" tests in which certain sections of tests can be bypassed depending upon the student's performance on "indicator" items.

COMPUTER COSTS FOR INSTRUCTIONAL USE

Costs are a serious consideration, and if computer-assisted education cannot be cost-effective, then it can be nothing more than a toy for educational researchers.

Conventional elementary education costs about $0.35 per student contact-hour. In universities, instructional costs run about $2.00 per instructional hour per student, with some lab courses near $10.00 per hour. In mass lecture classes, college instruction averages around $0.60 per student-contact-hour. Graduate education can run as high as $25.00 per hour.

At Florida State University, for example, CAI costs for an introductory Physics course ran $4.07 per instructional hour per student, and the same course in CMI mode cost some $1.79 per hour. (See Tables 1 and 2).

Florida State University has indicated a cost of some $240,000 for development of a freshman level CAI course. Ohio State University has found this cost to be in the neighborhood of $280,000.

TABLE 1

Cost Analysis for a Collegiate CAI Physics Course and CMI Course Curriculum Development Project at Florida State University

CATEGORY	CAI ITEM COST	CMI ITEM COST
Curriculum Preparation		
Behavioral Scientist	12,000	0
Writers	12,000	1,300
Physicists	6,000	
	30,000	1,300
CAI Coding		
CAI Coding Personnel	12,000	4,300
Computer Time	10,000	3,500
	22,000	7,800
Film and Graphics Production		
Art Work and Service Cost	600	200
	600	200
Computer Programming		
Data Management Programming	54,000	0
Data Analyses Programming	15,000	0
	69,000	0
CAI Instructional Cost		
CAI Computer Costs	15,000	900
Proctors	3,000	0
	18,000	900
Experimentation		
Graduate Students	24,000	800
	24,000	800
Office and Clerical	10,000	0
University Overhead	60,000	0
TOTALS	239,000	11,000
Cost per Instructional Hour		
a. Development	$4.07	$1.04
b. Operations	$1.79	$ .59

TABLE 2

Costs of Development and Instructional Activities for the CAI Multi-Media Physics Project at Florida State University

	EXPENDITURES	PERCENT OF TOTAL COST
I. DEVELOPMENTAL COSTS		
A. Professional Manpower		
1. Curriculum Preparation		
Physics Writers	$30,000	10
Physics Faculty	25,000	9
Behavioral Scientists	42,000	15
Subtotal	97,000	34
2. Computer Programming & Coding		
CAI Coding	12,000	4
Data Management Programming	40,000	14
Data Analysis Programming	24,000	8
Subtotal	76,000	26
3. Experimental Studies Support		
Graduate Students	24,000	8
Subtotal	24,000	8
4. Administration		
Director	11,250	4
Secretaries	15,000	5
Subtotal	26,250	9
B. Computer and Materials Costs		
1. Computer Time	9,000	3
CAI Coding	9,000	3
Systems Programming	25,000	9
Data Analysis	9,000	3
Subtotal	43,000	15
2. Media Preparation		
Films and Graphics	6,000	2
Audio	2,000	1
Subtotal	8,000	3
TOTAL DEVELOPMENTAL COSTS	$274,250	95

(TABLE 2 continued on next page)

TABLE 2 (continued)

	EXPENDITURES	PERCENT OF TOTAL COST
II. INSTRUCTIONAL OPERATIONAL COSTS		
A. Manpower		
Proctor	3,500	1
Computer Operators & Technicians	4,500	2
Subtotal	8,000	3
B. Computer and Film Costs		
Computer	6,000	2
Film Rental and Audio	1.250	
Subtotal	7,250	2
TOTAL INSTRUCTIONAL COSTS	$15,250	5
TOTAL PROJECT COSTS	$289,500	100

Bunderson (1970) surveyed cost estimates for the production of high quality CAI programs and found that the costs varied widely. For example, in a study conducted for the Committee on Economic development by Booz-Allen & Hamilton (1968), estimates of $30,000 per hour of tutorial instruction and $5,000 per hour of drill and practice were used for the basis for projections. These estimates were obtained from early experience in CAI at Stanford University. They seem quite high according to the experience of other CAI laboratories. For the CAI and multimedia physics course at Florida State University, estimates of $5,280 per hour of tutorial CAI with multimedia adjuncts and $3,860 per hour for revision. At the University of Texas, for a program in mathematics prerequisite to freshman science, estimates of $10,000 per student hour were obtained. By starting from a programmed textbook already written, a program in English punctuation and usage was developed at the University of Texas for about $4,700 per hour. It should be remembered that these are developmental costs per hour of instruction and are not amortized according to student usage over several years.

At best, Bunderson predicts that current CAI practitioners can produce good tutorial CAI programs for somewhere in the neighborhood of $3,000 per hour. This assumes the existence of languages, systems, and authoring techniques that are still in the developmental stages.

TWO STATE-OF-THE-ART SYSTEMS

The PLATO system developed at the University of Illinois (12) is a computer-based teaching system to provide teachers a means for individualizing student instruction. The teacher designs the instructional material; the computer presents the material; to the students and monitors and evaluates their performance, and students interact with the computer providing information on lesson effectiveness. The system is designed to facilitate easy revision of the instructional material. The intention of PLATO is to free the teacher for special work with students which conventional teaching styles do not usually permit.

The CAI terminal system consists of a slide selector, a storage tube, and a keyboard for student response.

A goal of the PLATO system is to provide instruction at $0.35 to $0.50 per student per terminal hour.

An innovative CAI system based on cable TV and conventional telephone systems is being developed jointly by the MITRE Corporation, the University of Texas, and Brigham Young University. The system has been termed TICCIT, for Time-shared, Interactive, Computer-Controlled Information Television (20).

This system includes the use of audio and color TV displays in the student terminals to provide voice-accompanied, multicolored alphanumeric and graphic displays, as well as full-color movies. A pair of minicomputers provides the necessary computer power in a self-contained system of terminals. The hardware system currently costs around $450,000 today for one complete, self-contained system with terminals, and a projected cost of less than $250,000 in moderate quantities. The TICCIT system has the capability of delivering CAI and other socially relevant computer services via cable TV to homes.

Validation of course material on a prototype version of the system is scheduled to begin in January, 1973. The courseware is directed toward the community college curriculum, and full scale demonstration is scheduled for two community colleges in September, 1974.

SOME CAI PROJECTS IN NORTH CAROLINA

There is considerable activity in the CAI area in North Carolina, primarily centered in the School Computer Service Corporation, the University of North Carolina at Chapel Hill, and the Triangle Universities Computer Center (TUCC). The latter provides computing services to public schools and community colleges through the North Carolina Educational Computing System (NCECS).

The School Computer Service Network in Raleigh: Several school districts in North Carolina have pooled their resources and formed a nonprofit corporation, the School Computer Service Corporation, and are in the process of paying for a GE265 computer system that is currently being used for instruction. The school districts have shared the costs of purchasing the computer, and after the purchase has been completed the costs of their data processing will decrease dramatically. The schools teach a number of courses using local terminals. One of the most interesting is the Engineering Concepts Curriculum Project (ECCP). ECCP is a course for Juniors and Seniors in high school with one year of algebra. The program introduces modern technology in a cultural context, and deals with the interface of society and technology. The course introduces the systems approach to problem solving. Ted Blakeway, Secretary of the School Computer Service Corporation, has been instrumental in developing and implementing the ECCP programs.

The Charlotte/Mecklenburg School System. In the Charlotte/Mecklenburg School System the business education department has installed IBM 1050 terminals in each of the ten senior high schools for the primary purpose of teaching programming courses. For the past two years, IBM 1620 Computers were used in eight schools offering this course.

Last year an experiment was conducted at Harding High School to determine if a change-over from the 1620 Computer to the 1050 Computer Terminal would be advisable. Pupil acceptance and advisability from a teaching standpoint to the change-over was assessed by a student survey and student programming accomplishments. Many students were able to progress further using the terminal, and more programs were processed by each student. Moreover, the teachers were freed from some routine duties required by the computer thus enabling them to spend more time teaching. At the end of the year, a survey of students showed there was a strong student preference for using the terminal to learn computer programming.

One of the major features of the program is that the computer terminal is connected by voice grade telephone lines to the IBM 370/165 computer at the Triangle Universities Computer Center (TUCC) located at the Research Triangle Park between Raleigh and Durham.

Each of the local high schools has one computer terminal unit consisting of a punched card input device, terminal keyboard, console printout, one telephone, and five keypunch machines. The keypunch machines are also used in the regular business education curriculum which includes office practice, cooperative office occupations, and a semester of keypunch instruction. The terminal is also available to all students and teachers in the school on a time-available basis.

The telephone network enables the data processing teachers to call for assistance as well as contact each other when the need arises. This provides each teacher with the facility of obtaining immediate assistance as the situation demands.

Some of the units covered in the computer course curriculum guide include the following: Historical Development of Computers, Classification of Computers, Computer Applications, Computer Internal Operations, Logic, Development of Algorithm and Flowcharting, Terminal Operations, and Basic Programming Principles.

An Overview of CAI in the Department of Computer Science at UNC - Chapel Hill: Computer system scientists are essentially tool-builders; a tool-builder must stay close to the tool-user, lest he build useless or even dangerous tools. For this reason, a major part of UNC's computer systems research program is associated with computer-assisted instruction. Instruction is an area in which educators are tool-users, hence the everyday problems and experiences of educators can be used to guide, test, and evaluate computer systems developments. It is hoped and expected that the computer systems developments will be useful in many applications other than instruction. They are tested in instruction because it is convenient, and we have first-hand knowledge of that application.

The subject of instruction at UNC happens to be computer science, but the techniques investigated are not peculiar to computer science and are applicable to many topics of instruction. Particular care is given to maintaining the distinction between computer-related techniques and computer-related subject matter, even when techniques are being explored that are peculiar to computer-related subject matter.

The current CAI work at UNC falls into several project areas, which may roughly be classified into student-controlled CAI, teacher-controlled CAI, and author-controlled CAI.

TIME-SHARING SYSTEMS APPROACH

Time-sharing can be an effective method of providing these services to a wide array of users with unique requirements. Time-sharing can be an effective instructional tool, due to convenience of use and immediate reinforcement of student solutions and inquiries. However, cost can prohibit the offering of time-sharing services because time-sharing is usually available only through large-scale computer systems designed to service hundreds of interactive terminals.

The University of Minnesota, at Minneapolis,* is currently successfully using a shared-system method. Under this approach, an educational organization can contract for that part of a computer system which will satisfy its time-sharing needs. The usual contract is for a minimum of one quarter of a system and carries with it various requirements.

The benefits of such an approach are:

1. Knowing that expandability of service is linear at a known fixed cost per port, making expansion easily budgeted and regulated;

2. Replacing a very small and inadequate system with a large-scale system and capability.

3. Enabling the creation of an educational network for public and private schools, junior colleges, colleges, and universities. One resource is the Region IV Education Service Center at Houston, Texas. Region IV is the most active Service Center in Texas in educational data processing. Its computer services component is an integrated part of a statewide network being developed. Region IV's computer configuration includes a CDC 6600 Time-sharing Computer, 12 Remote Job Entry Terminals (RJEs), and 135 Remote Teletypewriters (TTYs) - all connected to the central computer by telephone. Services performed include both instructional and administrative applications. The RJEs permit instruction in vocational data processing and on-line administrative services. The TTYs are located on school campuses and can be used for problem solving by math and science students. Administrative applications include Student Scheduling, Grade Reporting, Attendance Accounting, Test Scoring and Analysis, Payroll, Financial Accounting, and Tax Accounting. Special projects using the computer include Student Health and Nutrition, and Occupational Data Bank (for student or counselor inquiry). The concept of Region IV's computer operation is one of multiple services to multiple users from a single computer utility. The mode of operation includes in-house batch and remote batch processing, remote data file management, and remote instructional time-sharing.

4. Potential Computer Utility in support of Government and Industry as well as education.

IN CONCLUSION

To date, CAI has been a financial failure, despite instructional research that has demonstrated the effectiveness of CAI. The initial

* User of CDC Cyber 70 system under KRONOS Time-sharing Operating System.

failures of CAI can be attributed to many factors: oversell of its capabilities, poorly authored educational content, expensive and unreliable hardware, an educational bureaucracy resistant to innovation, and the decentralized structure of education in the U. S. which necessitates thousands of school systems having to be sold individually on the idea.

The computer can be a valuable instructional tool, and evaluation of CAI has tended to support the following conclusions:

CAI, across aptitude ranges, can be as effective as or better than conventional instruction in terms of improving student performance on achievement tests.

CAI has the capability to reduce instructional time to a significant degree, relative to conventional instruction.

Students taught by CAI are, on the average, favorably disposed toward CAI.

Systematic application of CAI and CMI can be a definite benefit to most educational programs, and current work portends significant reduction in the cost of computer-assisted instruction.

Past and recent CAI activities have indicated a need to ponder several considerations. The following 13 questions are from the article: "Basic Questions Concerning CAI and CMI" by Latta and Gilbert (16). The adaptations of the questions are presented by permission of CCM Professional Magazines Inc., publishers of College Management in which the original version of the article was printed.

1. Have needs been assessed and project objectives documented?

With emphasis on accountability approaching an all-time high, educators should be conducting needs assessment studies, especially when scarce resources will have to be allocated or rearranged. Such a study is especially essential for CAI and CMI, since the use of technology is not "just for fun." It demands a systems approach to educational problem solving. Such an approach entails the following steps:

a) Setting goals and translating them into objectives;

b) Gathering data on how effectively each objective is currently being met;

c) Assigning priorities to needs in order to close the gap between where the college is and where it ought to be;

d) Generating alternative ways to meet the high-priority objectives;

e) Selecting and implementing the solutions that offer the best cost-effectivness ratio;

f) Evaluating the operating system;

g) Modifying the system based upon feedback;

h) Continuously monitoring the system.

The above approach is an iterative and essential process for education considering CAI. If CAI is not a plausible solution to a high-priority need, then why bother considering it further? If, on the other hand, CAI does offer the best cost-effectiveness ratio, then one should proceed. Taking a systems approach provides the educational administrator with predetermined objectives which will permit rigorous evaluation later.

2. Have priorities been established for use on the CAI system before making a firm commitment to it?

Administrators tend to view CAI as one mode of instruction for limited use by faculty and students. Such is not the case. CAI can provide a variety of modes of instruction: drill and practice, tutorial or socratic, problem solving, testing, and gaming and simulation, to mention a few.

Once installed, the system can be used for basic and/or applied research. Several key questions, however, need to be answered before a computer-assisted instruction system is installed. Will the system be used predominantly for introductory purposes or primarily for instruction? Will it be used in conjunction with large or small classes? Or will it be used for both?

Consideration must be given to the above points prior to committing resources to the project.

3. Are the resources being committed to the CAI system stable?

Having selected CAI as the best cost-effective solution to a top-priority need and having considered the uses of the system, the administrator is in a good position to allocate resources. Budgeting should be long-term.

Once dollars have been assigned to the system so that objectives can be realized, one cannot use the system as the "fat lamb." Suppose, for example, that your organization has to cut back financially. Many schools in this position have looked on CAI as being an extra frill; as such, it is the first to be cut back or dropped.

If your organization tends toward this philosophy -- if commitments are not firm -- forget CAI. Cutbacks will prevent you from realizing accrued benefits from the system, and too little investment is worse than nothing at all. Managers may be far better off investing the few dollars in another high-priority need.

4. Are you aware of the dangers of adopting an existing CAI system?

In an effort to make a few dollars go a long way, an administrator may consider borrowing what has proven successful elsewhere. If the objectives for the two systems are very similar, then you may gain from such an investment. If, on the other hand, a system is superimposed simply for economic reasons, then forget it. There is no guarantee that success can be

transposed. In fact, a school might consider itself fortunate if the superimposed system turns out to be just slightly less effective than the existing one; it could conceivably be much less effective.

5. Have you addressed the need to release faculty for planning and program development?

You cannot expect faculty to plan, develop instructional strategies and write programs as an overload. If this is the policy, very little production and development will take place. Released time over an extended period is essential. To develop a CAI program one hour in length can take anywhere from 100 to 600 days, on the basis of one hour overtime per day.

6. Have you thought of training a core of CAI specialists?

It is a waste of resources to attempt to train every instructor in CAI skills and to permit many individuals unlimited travel to visit successful CAI projects and attend national conferences.

When a school gives released time, the administration must realize that the first year will be basically a learning experience. One can expect significant contributions from this trained staff over the following years, provided their released time is extended. Thus, if one does not emphasize the training of a few selected faculty members, the feasibility of proceeding beyond the training stage is minimal.

7. Are you planning to adjust the faculty load formula?

This reward structure is implicit in the two considerations above. While a few individuals may need to be released full time, half time released for software development would not be considered liberal by any means. Anything less will have little motivational effect on the instructor. Released time for the development of instructional programs must be formalized in terms of a faculty member's teaching responsibility.

8. Have you considered how CAI will affect other aspects of your instructional system?

Any addition, especially CAI, to one area of the instructional program will produce changes in other parts of the system. Administrators must give careful consideration to the manner in which departments, schools, and individuals interact and interrelate. Failure to view the institution as a whole system of parts acting together to accomplish predetermined goals or objectives may result in a loss of benefits from the installment of CAI.

9. Are you planning to integrate the CAI system into the total school program?

A corollary to Question 8 is that CAI activities should not be isolated from the instructional program. If other faculty members perceive the system as belonging to the math department, for example, cross-departmental implementation is limited. Chances are the CAI system will never spread beyond the originator. The CAI system should be considered a school-wide system.

10. Have you thought about the location and type of facilities to house the terminals?

How many terminals should each department have? Or should the terminals be located in a few centralized facilities? If so, where? Decisions on such questions affect faculty members' perceptions of who owns the system. Terminals must be within easy reach of all, and the terminal laboratory, if there is to be one, should receive the same consideration as the library.

11. Are you planning a school-wide orientation program?

If administrators, staff and faculty not directly involved with CAI are to understand the system and accept the concept of released time for software developers, they must be included in the orientation program. To exclude these individuals could impair full implementation. Furthermore, if the administration desires CAI usage to grow and spread, orientation needs to be initiated at all levels.

12. Have you attempted to avoid wasting the students' time?

If CAI is to be perceived by the student as desirable and effective, the system must not only be accessible, but there must not be a long wait at the terminal. Scheduling students on a first-come, first-served basis, runs the risk of queue formation. If a student has to stand in line for a considerable time to get a terminal, it is doubtful that he will maintain a positive attitude for long. In this regard, some time and utilization studies can be useful. Remember, if the school is doing its job a student has not time to waste. Management decisions must reflect this kind of thinking.

13. Do you view CAI as implying a team approach with you as a team member?

No individual has sufficient wisdom, time and energy to plan and implement CAI by himself. It takes a team effort with people involved both directly and indirectly. Exclusion of any member of the school community will tend to dampen the effectiveness of the CAI system. Administrators should be active members of any CAI team. A signature on an order, representing dollars alone, is not enough. If CAI/CMI is to be effective and make any kind of constructive contribution to learning in our schools, the managers must outnumber the administrators.

If you can answer yes to the 13 questions above, you have achieved a high level of awareness of the complexities of CAI. This is a big step in the right direction, but there still remains a long way to go.

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